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Exploring uncertainties in climate model simulations of the impacts of land-cover change on Asian monsoon climate

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A series of a global model 54-yr integrations using multi land-surface configurations have been conducted to allow us to explore the degree of uncertainty in the model land-use simulations caused by land-surface modelling itself and compare the model-simulated land-use signal to its intrinsic variability. Results showed that imposed land-use changes can alter regional climate simulated by the model, largely due to changes in surface albedo and surface roughness. Such processes are affected in only a secondary manner by different land-surface modelling configurations. Furthermore, using an extreme vegetation change scenario by replacing all its potential vegetation with mixed farming, the model-simulated reduction in summer monsoon precipitation and the cooling effect in northern winter season are nearly doubled, while the warming effect in its summer season remain the same. Due to strong rainfall variations in the Asian monsoon, land-use climate impacts operate effectively under two different regimes of surface energy balance: radiation-controlled and evaporation-controlled. Furthermore, comparing the global climate model results with high resolution regional climate model simulations reveals the reason why changes in rainfall show a similar pattern in northern winter, while the summer rainfall response to LUC shows opposite features between the model experiments. Despite of the differences in model-simulated summer rainfall responses, reduction in surface roughness is the outstanding factor in both models in explaining how LUC can affect monsoon rainfall. Results in this study also highlight the importance of improving model capability in simulation monsoon climate for reliable climate change projections in the region.